Indian Journal of Entomology 82(2): 280-284 (2020) DoI No.: 10.5958/0974-8172.2020.00065.6

SEASONAL INCIDENCE OF TOMATO PIN WORM *TUTA ABSOLUTA* (MEYRICK)

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ABSTRACT

Observations on the seasonal incidence of the tomato pin worm *Tuta absoluta* (Meyrick) (Lepidoptera: Gelechiidae) revealed that the occurrence was less during early stage of the crop, but later increased. The effect of weather factors evaluated during 2017-18 to 2018-19 revealed a positive correlation with the maximum temperature, and a negative one with relative humidity and rainfall.

Key words: Tomato, *Tuta absoluta,* foliage, fruit damage, population dynamics, temperature, relative humidity, rainfall, correlation coefficients

Tuta absoluta (Meyrick) (Lepidoptera: Gelechiidae), an invasive pest on tomato, known as tomato leaf miner/ pinworm is an oligophagous pest also associated with other solanaceous crops. India is the second largest producer of tomato with a productivity of 31.58 mt/ha (Anon., 2018). The production of tomato is affected due to various factors including pests and diseases. The tomato pinworm has now assumed a major pest status in India, and it is an invasive pest, being major pest in the South American region since 1960s (Garcia and Espul, 1982) and it is native to South America (Urbaneja et al., 2013). It was observed for the first time on tomato in India, from Maharashtra during October, 2014 (Shashank et al., 2015) and in Karnataka at ICAR-Indian Institute of Horticultural Research (ICAR-IIHR), Hessaraghatta, Bengaluru, during rabi 2014 (Sridhar et al., 2014). It causes reductions in yield and fruit quality up to 100% both in greenhouses and open fields (Shashank et al., 2015; Daniel et al., 2017). Larvae feed on leaves, buds, stem and fruits of tomato. Fruit rot occurs due to secondary invasion of pathogens into the fruits bored (Daniel et al., 2017). The information on foliage and fruit damage across the seasons would help to design IPM strategies. Hence, this study on the seasonal incidence in relation of weather factors.

MATERIALS AND METHODS

Arka Rakshak, a popular variety of tomato was grown with seeds sown in portrays in the poly house of the Vegetable Science Division during rabi 2017, summer and kharif 2018. Mainfield was prepared appropriately and 25 days old seedlings planted with row-to-row and plant to plant spacing of 90 and 60 cm, respectively. Gap filling was done after one week of planting up to 15 days, and crop raised as per the package of practices of University of Horticultural Sciences, Bagalkot, except pest management (Anon., 2017). Two blocks of 5x101.2 m^2 maintained separately to observe weekly data on the population of tomato pinworm and its natural enemies, in randomly selected and tagged 25 plants. Observations started with seven days after transplanting (DAT). The leaf damage was computed in %, and likewise the fruit damage also. The weekly weather data on maximum and minimum and mean temperature (°C), morning and noon relative humidity (%) and total rainfall (mm) were obtained from the Agro Meteorological Observatory of MHREC, UHS, Bagalkot.

RESULTS AND DISCUSSION

In rabi 2017-18, the leaf damage by *T. absoluta* was observed to range from 5.00 to 90.44%, first observation being in the second week of November 2017 (45^{th} SW), with the maximum being during the 15^{th} SW (2^{nd} week of April 2018); moderate damage was from 50^{th} SW to 6^{th} SW (2^{nd} week of December 2017 to that of February 2018). The correlation coefficients with weather factors revealed a significant positive relationship with maximum (r= 0.89), minimum (r=0.68) and mean temperature (r=0.82); it was a significantly negative one with morning (r=-0.73) and noon humidity (r=-0.66); and with rainfall it was a non-significant negative one (r =-0.18). Multiple regression analysis showed that all the weather parameters contributed to significant variation in damage (R^2= 89%). The fruit damage was observed to range from 20.00 to 85.00%, initially it was observed during first week of January 2018 (1^{st} SW) and reached 85% later (15^{th} SW). The correlation coefficients revealed that the fruit damage had shown significant positive correlation with maximum (r= 0.90), minimum (r=0.62) and mean temperature (r=0.80); humidity showed significantly negative one and rainfall showed a non-significant negative one. Multiple regression analysis revealed a R^2 value of 94% effect of weather factors on fruit damage during cropping period (Table 1,2).

In kharif 2018, the leaf damage ranged from 20.00 to 96.56% with initial damage observed during first week of July 2018 (27^{th} SW) reaching 50.00 to 96.56% (33^{rd} SW to 41^{th} SW 2018). Correlation coefficients with minimum temperature and morning relative humidity showed non- significant negative correlation,

Table 1. Incidence of *T. absoluta* and correlation with weather factors- leaf damage (2017 -18, 2018-19)

S. No.	Rabi (2017 -18)		Kharif 2018		Rabi 2018-19		Summer 2019	
	SW	Damage (%)	SW	Damage (%)	SW	Damage (%)	SW	Damage (%)
1	44	0.00 ± 0.00	25	0.00 ± 0.00	39	0.00 ± 0.00	49	15.00 ± 10.90
2	45	5.00 ± 5.00	26	20.00 ± 12.11	40	0.00 ± 0.00	50	25.00 ± 16.46
3	46	10.00 ± 5.95	27	20.00 ± 12.06	41	5.00 ± 4.20	51	28.00 ± 17.74
4	47	15.00 ± 7.72	28	30.00 ± 13.78	42	4.56 ± 3.91	52	30.00 ± 16.46
5	48	20.00 ± 10.38	29	35.00 ± 16.00	43	5.00 ± 4.21	1	35.00 ± 16.52
6	49	22.12 ± 11.90	30	40.00 ± 12.07	44	10.00 ± 4.79	2	40.00 ± 12.42
7	50	25.16 ± 10.71	31	46.59 ± 14.74	45	10.00 ± 4.33	3	46.56 ± 9.40
8	51	25.48 ± 14.36	32	48.59 ± 9.96	46	10.00 ± 5.40	4	65.00 ± 19.21
9	52	25.36 ± 15.73	33	50.00 ± 11.79	47	50.00 ± 14.89	5	70.00 ± 18.50
10	1	25.88 ± 17.35	34	51.26 ± 12.38	48	56.00 ± 17.57	6	78.26 ± 13.74
11	2	25.68 ± 18.89	35	55.69 ± 11.95	49	50.00 ± 15.13	7	82.00 ± 5.77
12	3	25.40 ± 21.39	36	55.98 ± 12.48	50	56.00 ± 18.71	8	88.00 ± 8.64
13	4	25.96 ± 10.36	37	58.00 ± 12.79	51	70.00 ± 18.67	9	83.00 ± 6.18
14	5	31.80 ± 12.02	38	60.00 ± 11.36	52	78.00 ± 13.82	10	85.00 ± 6.67
15	6	37.00 ± 18.76	39	89.97 ± 5.84	1	86.00 ± 7.59	11	88.00 ± 8.02
16	7	42.83 ± 22.82	40	90.00 ± 4.19	2	80.00 ± 14.20	12	90.00 ± 5.58
17	8	44.84 ± 21.35	41	96.56 ± 1.22	3	80.00 ± 14.12	13	90.00 ± 5.55
18	9	53.72 ± 16.61	42	90.00± 1.00	4	84.00 ± 6.67	14	95.00 ± 4.03
19	10	66.17 ± 14.49	43	90.00± 1.00	5	90.00 ± 5.58	15	93.26 ± 5.69
20	11	73.57 ± 12.87	44	85.00± 2.55	6	92.16 ± 5.51	16	90.00 ± 10.82
21	12	81.92 ± 12.15	45	80.00± 10.0	7	90.00 ± 10.82	17	95.00 ± 4.18
22	13	84.68 ± 11.81	46	80.00± 5.50	8	91.00 ± 9.15	18	96.00 ± 6.22
23	14	87.36 ± 11.45	47	80.00± 2.50	9	90.00 ± 9.49	19	95.00 ± 4.38
24	15	90.44 ± 9.82	48	80.00± 1.22	10	90.00 ± 9.53	20	95.00±1.50

Parameters	Maximum temperature (°C)	Minimum temperature (°C)	Average temperature (°C)	Morning RH (%)	Noon RH (%)	Rainfall (mm)
Rabi (2017 -18)	0.89*	0.68*	0.82*	-0.73*	-0.66*	-0.18 NS
Kharif 2018	0.53*	-0.29 NS	0.38 NS	-0.37 NS	-0.63*	0.28 NS
Rabi (2018-19)	-0.04 NS	-0.73*	-0.53*	-0.32 NS	-0.68*	-0.36 NS
Summer 2019	0.87*	0.70*	0.81*	-0.54*	-0.79*	-0.35 NS

Dependent factors (Y)	Prediction model (Regression equation)	F value	R^2
Rabi (2017-18)	$Y = -53.970 + 429.755\ X_1 + 430.063\ X_2 - 854.325\ X_3 - 0.887\ X_4 + 0.014\ X_5 - 0.465\ X_6$	1.88	0.89
Kharif 2018	$Y = 333.529 + 968.490\ X_1 + 971.782\ X_2 - 1946.355\ X_3 - 0.964\ X_4 - 1.345\ X_5 + 1.573\ X_6$	0.06	0.63
Rabi (2018-19)	$Y = 161.958 + 109.852\ X_1 + 116.107 X_2 - 232.976\ X_3 + 2.349 X_4 - 3.747 X_5 - 0.268\ X_6$	2.19	0.82
Summer 2019	$Y = 93.776 - 365.959\ X_1 + 4.920\ X_2 - 368.329\ X_3 + 0.748\ X_4 - 3.400\ X_5 - 5.305 X_6$	5.56	0.85

SD: Standard Deviation; *Significant at 5%,NS: Non-significant; Y= Leaf damage (%); X_1= Minimum Temperature (◦C) X_2=Maximum Temperature (◦C) X_3=Mean Temperature (◦C); X_4=Morning relative humidity (%) X_5=Evening humidity (%) X_6=Rainfall (mm)

Table 2. Incidence of *T. absoluta* and correlation with weather factors- fruit damage (2017-18, 2018-19)

S. No.	Rabi (2017 -18)		Kharif 2018		Rabi 2018-19		Summer 2019	
	SW	Damage (%)	SW	Damage (%)	SW	Damage (%)	SW	Damage (%)
1	44	0.00 ± 0.00	25	0.00 ± 0.00	39	0.00 ± 0.00	49	0.00 ± 0.00
2	45	0.00 ± 0.00	26	0.00 ± 0.00	40	0.00 ± 0.00	50	0.00 ± 0.00
3	46	0.00 ± 0.00	27	0.00 ± 0.00	41	0.00 ± 0.00	51	0.00 ± 0.00
4	47	0.00 ± 0.00	28	0.00 ± 0.00	42	0.00 ± 0.00	52	0.00 ± 0.00
5	48	0.00 ± 0.00	29	0.00 ± 0.00	43	0.00 ± 0.00	1	0.00 ± 0.00
6	49	0.00 ± 0.00	30	0.00 ± 0.00	44	0.00 ± 0.00	2	0.00 ± 0.00
7	50	0.00 ± 0.00	31	0.00 ± 0.00	45	0.00 ± 0.00	3	16.02 ± 12.07
8	51	0.00 ± 0.00	32	0.00 ± 0.00	46	0.00 ± 0.00	4	45.89 ± 9.38
9	52	0.00 ± 0.00	33	18.00 ± 13.61	47	10.00 ± 5.40	5	50.00 ± 12.15
10	1	20.00 ± 7.27	34	25.00 ± 17.02	48	12.30 ± 7.95	6	50.00 ± 13.14
11	2	25.00 ± 17.02	35	23.00 ± 17.81	49	15.00 ± 12.83	7	55.00 ± 13.84
12	3	26.00 ± 18.39	36	20.00 ± 14.51	50	15.00 ± 12.83	8	70.00 ± 18.08
13	4	30.00 ± 10.70	37	30.00 ± 10.80	51	45.00 ± 21.23	9	75.00 ± 13.44
14	5	30.00 ± 10.80	38	35.00 ± 18.93	52	50.00 ± 15.13	10	75.00 ± 13.29
15	6	40.00 ± 17.38	39	38.00 ± 19.04	1	56.00 ± 14.80	11	70.00 ± 18.14
16	7	44.01 ± 14.11	40	36.00 ± 19.56	2	55.00 ± 14.00	12	78.00 ± 11.82
17	8	50.62 ± 17.38	41	40.00 ± 17.38	3	50.00 ± 15.00	13	85.65 ± 7.25
18	9	55.26 ± 15.10	42	38.00±10.50	4	56.00 ± 14.87	14	90.00 ± 5.55
19	10	59.26 ± 12.34	43	35.00±5.50	5	60.00 ± 15.06	15	90.00 ± 8.62
20	11	60.23 ± 11.76	44	35.00±5.50	6	60.00 ± 16.13	16	95.00 ± 4.03
21	12	68.59 ± 14.18	45	35.00±15.00	7	54.00 ± 14.24	17	90.00 ± 10.91
22	13	70.26 ± 12.46	46	35.00±5.00	8	45.00 ± 21.52	18	90.00 ± 9.82
23	14	73.26 ± 9.96	47	30.00±10.00	9	60.00 ± 15.06	19	90.00 ± 11.20
24	15	85.00 ± 6.30	48	30.00±10.00	10	70.00 ± 24.05	20	90.00±10.00

Parameters	Maximum temperature (°C)	Minimum temperature (°C)	Mean temperature (°C)	Morning RH (%)	Noon RH (%)	Rainfall (mm)
Rabi (2017 -18)	0.90*	0.62*	0.80*	-0.75*	-0.85*	-0.17 NS
Kharif 2018	0.41 NS	0.62*	0.41 NS	-0.44 NS	-0.71*	0.23 NS
Rabi (2018-19)	0.03 NS	-0.69*	-0.43 NS	-0.31 NS	-0.70*	-0.28 NS
Summer 2019	0.91*	0.81*	0.89*	-0.47 NS	-0.73*	-0.31 NS

Dependent factors (Y)	Prediction model (Regression equation)	F value	R^2
Rabi (2017 -18)	$Y = -35.768 + 310.903\,X_1 + 312.117\,X_2 - 618.872\,X_3 - 0.551X_4 - 0.429\,X_5 - 0.092\,X_6$	9.41	0.94
Kharif 2018	$Y = 160.942 + 424.731X_1 + 433.986\,X_2 - 863.359\,X_3 - 0.668\,X_4 - 0.348\,X_5 + 1.064\,X_6$	0.03	0.78
Rabi (2018-19)	$Y = 113.421 - 357.641\,X_1 - 354.427\,X_2 + 707.420\,X_3 + 1.751X_4 - 3.127X_5 + 0.626X_6$	8.05	0.83
Summer 2019	$Y = 43.019 - 874.717\,X_1 + 8.160\,X_2 - 878.009\,X_3 + 1.137\,X_4 - 4.158\,X_5 - 6.533X_6$	9.13	0.95

SD: Standard Deviation; * Significant at 5%, NS: Non-significant; Y= Fruit damage (%); X_1= Minimum temperature (◦C) X_2=Maximum temperature (◦C) X_3=Mean temperature (◦C); X_4=Morning relative humidity (%) X_5=Evening humidity (%) X_6=Rainfall (mm)

while maximum temperature (r =0.53) had positive significant correlation, and noon relative humidity (r=-0.63) had significant negative correlation; temperature and rainfall had positive significant correlation during cropping period with correlation coefficients r = 0.38 and r = 0.28, respectively. Multiple regression analysis revealed that the weather contributed significantly to the incidence (R^2 being 63%). Damage to the fruits was initially observed during second week of August (33rd SW) (18%) in the nine weeks old crop, it continued and reached its peak (40.00%) at the end of the crop during the second week of October (41st SW). The correlation coefficients with weather factors revealed a significant positive correlation (r = 0.62) with minimum temperature, and relative humidity had negative significant correlation (-0.71). Multiple regression analysis revealed a 78% contribution by weather factors (Table 1, 2).

During October 2018 to March 2019, leaf damage was observed from 41st SW of 2018 to 10th SW of 2019 and it ranged from 5.00 to 90.00. There was no damage during 39th and 40th SW of 2018. Correlation coefficients were- with minimum (r = -0.73), mean temperature (r =-0.53); and with noon relative humidity (r=-0.68); with weather factors contributing to 81%. As regards fruit damage, it commenced from third week of November (47th SW) with 10.00% and maximum of 70.00% during second week of March (10th SW). Mean temperature (r=-0.43), morning relative humidity (r=-0.31) and rainfall (r=-0.28) showed negative and non-significant correlations. Minimum temperature (r = -0.69) and noon relative humidity (r = -70) exhibited a significant negative correlation, with weather factors contributing an effect of 83% (Table 1, 2)

During December to May 2019, leaf damage ranged from 15.00 to 96.00%, with peak being 18th SW of 2019; correlation with weather factors revealed a highly significant positive correlation with maximum (r =0.87), minimum (r = 0.70) and mean temperature (r = 0.81); there existed a significant negative correlation with morning (r=-0.54) and noon humidity (r =-0.79); overall weather factors contributed %. The fruit damage commenced from third week of January (3rd SW) reaching maximum of 95.00% during 16th SW. The correlation coefficients revealed that the maximum temperature (r = 0.91) had a significant positive correlation, while minimum (r = 0.81) and mean temperature (r = 0.89) had significant positive one; noon relative humidity (r = -0.73) had significant negative correlation; and weather factors effected 83% to the fruit damage (Table 1, 2).

The present results are in conformity with earlier ones Andrew et al.(2013) on the population buildup ceasing at lower temperatures (7-10 °C) and increasing at higher temperatures (23 °C and above). Assaf et al. (2013) in poly house conditions at Iran observed a maximum damage during September. Simala et al. (2011) reported eight peaks, with five peaks in the summer plantations and three peaks in winter. Similarly, Cocco et al. (2015) observed the population to be low in winter and increased steadily in spring. The peak activity of T. absoluta was during second fortnight of January at Raichur (Anon., 2016). Taram (2016) noticed peak seasonal activity during February and March. Devaraj et al. (2017) observed a low leaf infestation (5.92%) during November 2015 and fruit damage (1.59%) during July 2015, whereas, maximum leaf and fruit damage (27.7 and 13.99%, respectively) were noticed during February 2016. Similarly, the maximum damage was during January to May and the least, during October to November. El-Badawy et al. (2017) also documented maximum damage in early summer and summer plantations. Nayana et al. (2018) recorded a low level both in kharif and rabi during first phenological cycle of crop, and it increased with age under both polyhouse and open field condition. Spakal et al. (2018) observed maximum fruit damage during 41st SW. Zekeya (2019) reported more population density in dry season than in rainy season. According to Bacci et al. (2019) population fluctuations during rainy season were very low.

The present results are supported by those of Cocco et al. (2015) as regards relationship with weather factors. Rrainfall had a negative relationship, and damage was very less in November. The peak incidence of leaf and fruit damage were during 10th SW of 2018. Damage had significant positive correlation with maximum and mean temperature while morning and noon humidity exhibited significant negative relation.

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(Manuscript Received: November, 2019; Revised: January, 2020; Accepted: January, 2020; Online Published: February, 2020)
Online published (Preview) in www.entosocindia.org Ref. No. 19186